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(54) FLEXIBLE CABLE

(71) We, AMP INCORPORATED, a corporation organised and existing under the laws of the State of New Jersey, United States of America, of Eisenhower Boulevard, Harrisburg, State of Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to flexible cables for transmission lines.

According to the present invention, a flexible cable for a transmission line comprises a flat flexible substrate of electrically insulating material having on one surface a signal conductor extending longitudinally of the cable but laterally offset from the longitudinal centre line of the substrate and on the opposite surface a ground conductor extending longitudinally of the cable, the cable being folded along the longitudinal centre line so that portions of the said one surface overlap each other contiguously, the signal conductor being sandwiched between portions of the ground conductor, which ground conductor in the unfolded condition describes a regular tortuous path extending laterally across said opposite surface of the substrate.

Embodiments of the invention will now be described by way of example, reference being made to the Figures of the accompanying diagrammatic drawings in which:—

Figure 1 is a plan view of a first embodiment of an electrical transmission cable prior to cutting and folding to form a shielded line;

Figure 2 is plan view of the first embodiment after cutting and folding to form a shielded line;

Figure 3 is a cross-sectional view taken along line 3—3 of Figure 2;

Figure 4 is a plan view of a second embodiment prior folding, to form a shielded line;

Figure 5 is a cross-sectional view taken along the line 5—5 of Figure 4 and showing the cable after folding; and

Figure 6 is a cross-sectional view of a third embodiment of cable folded to provide shielded transmission lines.

In the first example, a flat flexible insulating substrate 10 has a signal conductor 12 extending longitudinally of one face and a ground conductor 14 extending longitudinally of the opposite face, both of which can be formed by printing and etching techniques. The signal conductor is laterally offset from the longitudinal axis of the cable and the ground conductor describes a tortuous path of generally sinusoidal form and extends laterally across the substrate opposite the signal conductor to cover, in this embodiment, substantially the whole width of the substrate. A series of ground and signal termination pads 20 and 18 of enlarged area are formed at equal intervals along the ground and signal lines and corresponding signal and ground pads are laterally spaced apart and aligned.

The cable is cut transversely at 16, near the endmost terminal pads 18 and 20 of the signal and ground conductors, respectively, and folded to the condition shown in Figures 2 and 3 in which it can be retained by adhesives. Terminals 22 and 24 are then crimped to the pads either from the same or (as shown) opposite directions of the transmission cable. Soldered or other types of termination may be used but a crimped connection is preferred.

This example of cable is for use in high density wiring where it is desirable to provide controlled characteristic impedance with adequate electrical shielding and signal rise times in the nano-second region. The characteristic impedance of the folded transmission line is determined by the wave length or the pitch of the ground line as well as the thickness and dielectric properties of the substrate. The folded construction can also be utilised with a plurality of conductors, as will be discussed with reference to the second and third embodiments since the problem of critical alignment which would arise if the ground lines were parallel to the signal lines is obviated.

The second embodiment, (Figures 4 and

5), differs from the previous embodiment in that the substrate 54 has a plurality of parallel signal conductors 56 formed on one face laterally offset from the longitudinal centre line of the substrate and two ground conductor halves 58 and 60 formed on the opposite face, the ground conductor halves being laterally offset from and on opposite sides of the longitudinal centre line each describing a sinusoidal path which is a mirror image of the other. The cable can be folded and used in a similar fashion to the first embodiment. The ground conductor halves can be interconnected by terminals (not shown). In this embodiment the ground conductor halves are in phase when the substrate is folded but other patterns producing different phase relations could be used.

In the third embodiment, (Figure 6), a folded flexible insulating substrate 62 has a plurality of a signal conductor 64 on one face and two ground conductor halves 66 and 68 on the other face (in unfolded state). Alternate signal conductors are connected to both ground conductor halves by conductive means 70 to form a series of transmission lines similar, in many respects, to a coaxial cable. The connection of the conductors can be made by spot bonding, stapling, stitching with metallic wire, or other suitable methods.

Experimentation with samples of cable produced according to the present invention have shown that it has improved electrical transmission characteristics. The cable exhibited improved cross-talk characteristics, both cable to cable and channel to channel cross-talk, while providing reduced high frequency attenuation and stable characteristic impedance. The cable is relatively simple to manufacture since there is relatively little art work required and special cable processing for separate applications is eliminated.

In the first, second and third embodiments ground patterns obviate the problem of aligning ground and signal conductors and permit better cable to cable cross-talk characteristics than prior single ground and signal conductor cables. The characteristic impedance of the line is controlled by adjustment of the ground pattern pitch and can be determined within the ground pattern alone so that the alignment between the ground and signal patterns is no longer of critical importance. Moreover this provides a greater portion of the shielding directly over and under the signal conductors where it is most needed rather than to the sides of the signal conductors where radiation is relatively small.

WHAT WE CLAIM IS:—

1. A flexible cable for a transmission line comprising a flat flexible substrate of electrically insulating material having on one surface a signal conductor extending longitudinally of the cable but laterally offset from the longitudinal centre line of the substrate and on the opposite surface a ground conductor extending longitudinally of the cable, the cable being folded along the longitudinal centre line so that portions of the said one surface overlap each other contiguously, the signal conductor being sandwiched between portions of the ground conductor, which ground conductor in the unfolded condition describes a regular tortuous path extending laterally across said opposite surface of the substrate.

2. An electrical transmission cable as claimed in claim 1, in which the tortuous path is generally sinusoidal.

3. An electrical transmission cable as claimed in claim 1, in which first and second ground conductor halves are provided, the first and second ground conductor halves being laterally offset from and on opposite sides of the longitudinal centre line of the substrate each describing a generally sinusoidal path which is a mirror image of the other.

4. A flexible cable for a transmission line constructed and arranged substantially as hereinbefore described with reference to and as illustrated in Figures 1 to 3 or Figures 4 and 5 or Figure 6 of the accompanying drawings.

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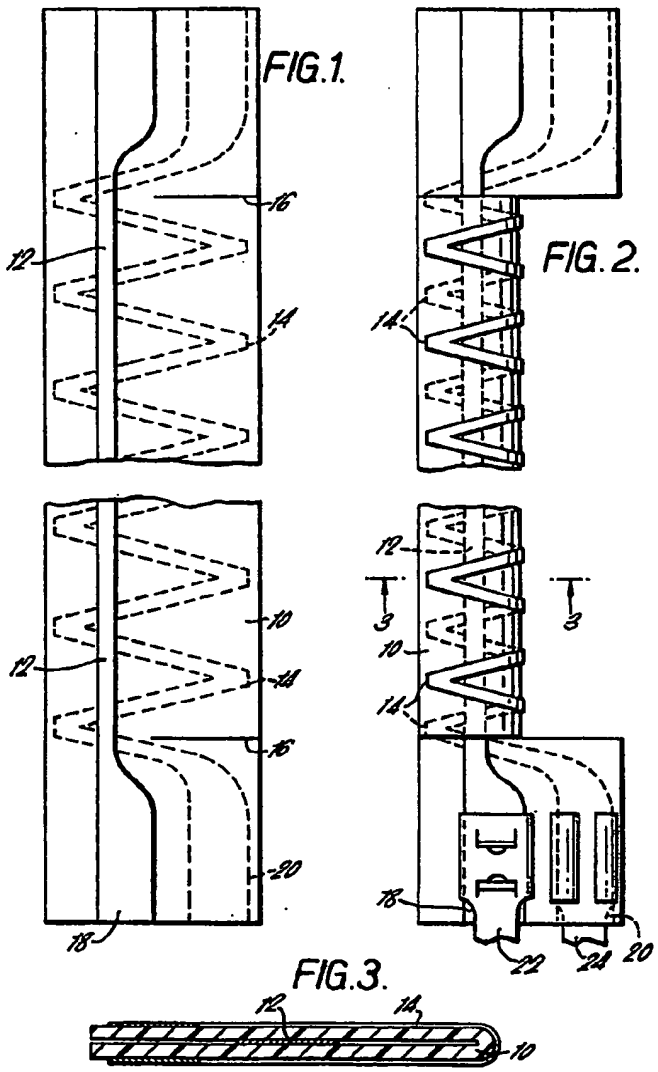
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1



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Sheet 2

FIG. 4.

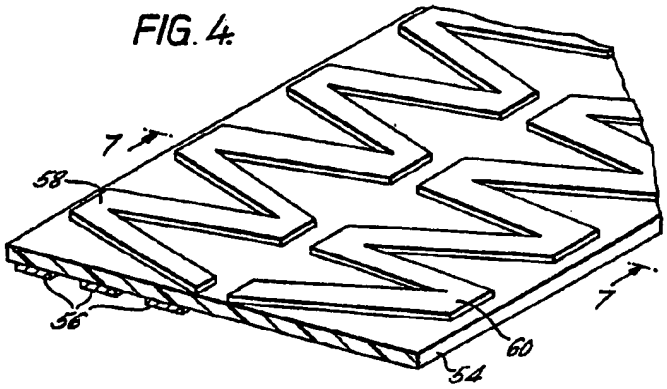

FIG. 5

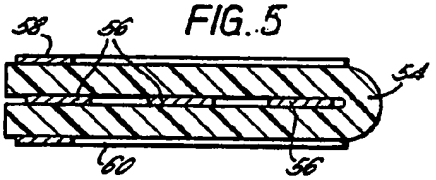

FIG. 6.